PATENT ABSTRACTS OF JAPAN

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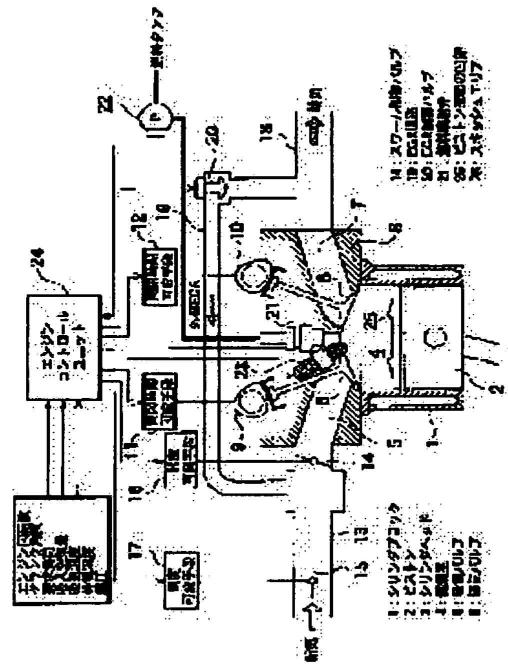
(54) INTERNAL COMBUSTION ENGINE OF COMPRESSION SELF-IGNITION TYPE USING GASOLINE

(57)Abstract:
PROBLEM TO BE SOLVED: To drop the cooling loss and drop the internal EGR gas amount for use as the thermal energy necessary for compression self-ignition combustion.
SOLUTION: The internal EGR gas remaining in a combustion chamber 4 due to minus overlapping of a suction 6 and an exhaust valve 8 is distributed in the central part of the chamber 4 by a swirling stream of fresh air, and around it, the fresh air is distributed and stratified, which allows the internal EGR gas to remain at a high temperature, and thereby the amount of internal EGR gas necessary for compression self-ignition combustion can be reduced to result is heightening of the thermal efficiency, and it is possible to reduce the cooling loss while the fresh air layer distributed in the peripheral zone of the combustion chamber 4 serves as a heat shutoff layer.



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CLAIMS

[Claim(s)]
[Claim 1] While having the inhalation-of-air system which can generate a swirl style in a combustion chamber, and the fuel injection valve which injects a direct fuel to a combustion chamber in the compressed self-ignition type gasoline internal combustion engine which you carry out [internal combustion engine] self-ignition of the gaseous mixture of a combustion chamber according to a compression operation of a piston, and makes it burn An exhaust air line is equipped [the closed stage (EVC) of an exhaust air bulb] with as controllable to the valve timing of minus overlap which becomes the middle a valve gear as an inhalation-of-air line by the open stage (IVO) of an intake valve on the way. While setting the valve timing of ** and an exhaust air bulb as said minus overlap by the compressed self-ignition operating range and making a part of exhaust air remain as internal EGR gas, new mind is introduced as a swirl style to a combustion chamber. While distributing said internal EGR gas layer in the center of a combustion chamber, distribute new mind over the perimeter and internal EGR gas and new mind are made to laminate. The compressed self-ignition type gasoline internal combustion engine characterized by mainly injecting and distributing a fuel over said internal EGR gas layer which laminated by said fuel injection valve, and making it make self-ignition combustion perform by the compression stroke.
[Claim 2] The compressed self-ignition type gasoline internal combustion engine according to claim 1 characterized by an inhalation-of-air line setting up the fuel injection timing of the fuel injection valve in a compressed self-ignition operating range during the period of a compression stroke from the second half.
[Claim 3] The compressed self-ignition type gasoline internal combustion engine according to claim 1 characterized by an inhalation-of-air line setting up the fuel injection timing of the fuel injection valve in a compressed self-ignition operating range twice during the period of a compression stroke from the second half during the minus overlap period of ** and an exhaust air bulb.
[Claim 4] While an inhalation-of-air line sets up the fuel injection timing of the fuel injection valve in a compressed self-ignition operating range twice during the period of the second half to a compression stroke during the minus overlap period of ** and an exhaust air bulb from low loading in an inside load region The compressed self-ignition type gasoline internal combustion engine according to claim 1 characterized by having brought the 2nd fuel injection timing forward with the rise of a load in the inside load region, and an inhalation-of-air line setting fuel injection timing as 1 time in the period of a compression stroke from the second half in a heavy load region.
[Claim 5] a compressed self-ignition type gasoline internal combustion engine given in any of claims 1-4 characterize by mix external EGR gas in new mind , and make it make it flow into a combustion chamber when it control and become more than a predetermined load so that it may become short with a rise of a load about the minus overlap period of ** in a compressed self-ignition operating range , and an exhaust air bulb they be .
[Claim 6] A compressed self-ignition type gasoline internal combustion engine given in any of claims 1-5 characterized by establishing a squish generating means to reach an intake valve arrangement side or to generate a squish style towards the center of cylinder head abbreviation from an exhaust air bulb arrangement side while establishing the crevice in the abbreviation center section of the piston crestal plane they are.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to a compressed self-ignition type gasoline internal combustion engine.
[0002]
[Description of the Prior Art] Compressed self-ignition combustion is NOx in exhaust gas since combustion is started by the multipoint of a combustion chamber, and the combustion by which whose rate of combustion was quick and the air-fuel ratio was stabilized also in the Lean condition compared with the usual jump-spark-ignition combustion is realizable, and and combustion temperature falls possible [improvement in specific fuel consumption]. It can also decrease sharply. [an air-fuel ratio]
[0003] Moreover, they are the high power reservation at the time of high rotation and a heavy load, the improvement in specific fuel consumption at the time of low rotation and the load in low, and NOx by making the usual jump-spark-ignition combustion perform in high rotation and a heavy load field, and changing a combustion gestalt from said jump-spark-ignition combustion to compressed self-ignition combustion in low rotation and the load field in low. Coexistence of reduction-izing can be aimed at.
[0004] when making compressed self-ignition combustion perform using the low fuel of self-ignition nature like a gasoline, it is effective to use the heat energy which residual gas has, and this is shown in JP,10-266878,A — as — like an exhaust air line — from — in case it shifts like an inhalation-of-air line, it realizes by establishing the sealing period when both an exhaust air bulb and an intake valve serve as close, and making the so-called internal EGR which produces residual gas positively perform.
[0005]
[Problem(s) to be Solved by the Invention] By the way, in order to make still more effective improvement in the specific fuel consumption by compressed self-ignition combustion, it becomes important to reduce the cooling loss from the combustion gas under combustion to a combustion chamber wall surface.
[0006] Also although the heat transfer rate from combustion gas to a combustion chamber wall surface becomes high in compressed self-ignition combustion since the gas consistency in a cylinder is high, and this calls it low-temperature combustion, the ratio of the energy lost as a cooling loss is for seldom falling.
[0007] However, if it is in said conventional configuration, in order to mix to the internal EGR gas and the homogeneity which were introduced into the combustion chamber where the fuel was injected by the suction port and mixed with new mind, and remained to the combustion chamber, To the top where the gas temperature in the combustion initiation time by internal EGR gas is high, generation of heat is performed also near the combustion chamber wall surface, reduction of the cooling loss to a combustion chamber wall surface cannot be aimed at, but the improvement effectiveness of the specific fuel consumption by compressed self-ignition combustion is no longer acquired fully.
[0008] Moreover, although internal EGR gas becomes the factor which conversion to the pressure of the generated heat energy is barred, and reduces an engine's thermal efficiency in order to reduce the ratio of specific beat of working medium Since homogeneity is made to mix gaseous mixture and internal EGR gas, for compressed self-ignition combustion generating, the amount of internal EGR gas will be needed for a large quantity, therefore it will become impossible to fully achieve the improvement effectiveness of the specific fuel consumption by compressed self-ignition combustion also by this with said conventional configuration.
[0009] Then, this invention reduces a cooling loss and offers the compressed self-ignition type gasoline

internal combustion engine which can heighten the improvement effectiveness of the specific fuel consumption by compressed self-ignition combustion while it can reduce the amount of internal EGR gas required for compressed self-ignition combustion.

[0010]

[Means for Solving the Problem] If it is in invention of claim 1, while having the fuel injection valve which injects a direct fuel to a combustion chamber in the compressed self-ignition type gasoline internal combustion engine which you carry out [internal combustion engine] self-ignition of the gaseous mixture of a combustion chamber according to a compression operation of a piston, and makes it burn An exhaust air line is equipped [the closed stage (EVC) of an exhaust air bulb] with as controllable to the valve timing of minus overlap which becomes the middle a valve gear as an inhalation-of-air line by the open stage (IVO) of an intake valve on the way. While setting the valve timing of ** and an exhaust air bulb as said minus overlap by the compressed self-ignition operating range and making a part of exhaust air remain as internal EGR gas, new mind is introduced as a swirl style to a combustion chamber. While distributing said internal EGR gas layer in the center of a combustion chamber, distribute new mind over the perimeter and internal EGR gas and new mind are made to laminate. A fuel is mainly injected and distributed over said internal EGR gas layer which laminated by said fuel injection valve, and it is characterized by making it make self-ignition combustion perform by the compression stroke.

[0011] If it is in invention of claim 2, it is characterized by an inhalation-of-air line setting up the fuel injection timing of the fuel injection valve in a compressed self-ignition operating range according to claim 1 during the period of a compression stroke from the second half.

[0012] If it is in invention of claim 3, it is characterized by an inhalation-of-air line setting up the fuel injection timing of the fuel injection valve in a compressed self-ignition operating range according to claim 1 twice during the period of a compression stroke from the second half during the minus overlap period of ** and an exhaust air bulb.

[0013] If it is in invention of claim 4, the fuel injection timing of the fuel injection valve in a compressed self-ignition operating range according to claim 1 from low loading in an inside load region During the minus overlap period of ** and an exhaust air bulb, While setting up an inhalation-of-air line twice during the period of a compression stroke from the second half, in the inside load region, it is characterized by having brought the 2nd fuel injection timing forward with the rise of a load, and an inhalation-of-air line setting fuel injection timing as 1 time in the period of a compression stroke from the second half in a heavy load region.

[0014] If it is in invention of claim 5, when it controls and becomes more than a predetermined load so that it may become short with a rise of a load about the minus overlap period of ** in a compressed self-ignition operating range according to claim 1 to 4, and an exhaust air bulb, it is characterized by mixing external EGR gas in new mind, and making it make it flow into a combustion chamber.

[0015] If it is in invention of claim 6, while establishing a crevice in the abbreviation center section of the piston crestal plane in a compressed self-ignition type gasoline engine according to claim 1 to 5, it is characterized by establishing a squish generating means to reach an intake valve arrangement side or to generate a squish style towards the center of cylinder head abbreviation from an exhaust air bulb arrangement side.

[0016]

[Effect of the Invention] According to invention according to claim 1, carry out an internal EGR gas layer in the center by the combustion chamber, distribute new mind over the perimeter, and these interior EGR gas layer and new mind are made to laminate. Reduction of a cooling loss can be aimed at because the new gaseous layer with low temperature which generates combustion in a part with much internal EGR gas of the center of a combustion chamber in order to inject a fuel mainly in this internal EGR gas layer, and is distributed near the cylinder head forms a thermal insulation layer between combustion gas and a combustion chamber wall surface.

[0017] Moreover, in this way, an elevated temperature is maintained without being mixed with new mind and homogeneity, internal EGR gas can raise a fuel to the temperature in which self-ignition is possible, since the amount of internal EGR gas required for compressed self-ignition combustion can be lessened, thermal efficiency can be improved, and specific fuel consumption can be conjointly improved much more with the ability of said cooling loss to be reduced.

[0018] Since the inhalation-of-air line by which lamination with an internal EGR gas layer and a new gaseous layer is stabilized injects and distributes [according to invention according to claim 2] a fuel over this internal EGR gas layer from the second half during the period of a compression stroke in

addition to the effect of the invention of claim 1, combustion generating in a combustion chamber central part can be made to ensure.

[0019] According to invention according to claim 3, to the effect of the invention of claim 1 In addition, during the minus overlap period of ** and an exhaust air bulb, Namely, a radical can be generated and proliferated by making the 1st fuel injection perform immediately after confining hot internal EGR gas in a combustion chamber. In order to carry out the internal EGR gas layer which generated this radical and was proliferated according to swirl generating like an inhalation-of-air line in the center, to distribute a new gaseous layer over that perimeter and to laminate, a radical is held good. In order for the inhalation-of-air line by which lamination with this internal EGR gas layer and a new gaseous layer is stabilized to make the 2nd fuel injection perform in the internal EGR gas layer in which this radical was held during the period of a compression stroke from the second half, While being able to make combustion generating in a combustion chamber central part able to ensure and being able to stabilize compressed self-ignition combustion, the amount of internal EGR gas required for compressed self-ignition combustion can be lessened further.

[0020] According to invention according to claim 4, it adds to the effect of the invention of claim 1. A compressed self-ignition operating range from low loading in an inside load region During the minus overlap period of ** and an exhaust air bulb, Namely, by making the 1st fuel injection perform immediately after confining hot internal EGR gas in a combustion chamber, partial oxidation of a fuel can be urged and a fuel can be reformed. In order to distribute a new gaseous layer over that perimeter and to laminate, where it carried out the internal EGR gas layer which contains this reforming fuel according to swirl generating like an inhalation-of-air line in the center, and reforming of the fuel is carried out, it is held good. In order for the inhalation-of-air line by which lamination with this internal EGR gas layer and a new gaseous layer is stabilized to make the 2nd fuel injection perform in the internal EGR gas layer in which this reforming fuel was held during the period of a compression stroke from the second half, Even if it is a little fuel, while being able to make combustion generating in a combustion chamber central part able to ensure and being able to stabilize compressed self-ignition combustion, the amount of internal EGR gas required for compressed self-ignition combustion can be lessened further.

[0021] And in order to bring the 2nd fuel injection timing forward with a rise of a load in an inside load region, the rise of the combustion temperature by concentration of too much fuel of a combustion chamber is controlled, and it is NOx. The increment in an yield is avoidable.

[0022] Furthermore, since said inhalation-of-air line sets fuel injection timing as 1 time in the period of a compression stroke from the second half, it is avoidable that the generating stage of self-ignition combustion serves as **** in a heavy load region.

[0023] Consequently, the compressed self-ignition combustion stabilized more in the large load range ranging from the low loading region to a heavy load region can be made to perform.

[0024] According to invention according to claim 5, it adds to the effect of the invention of claims 1-4. In order to shorten the minus overlap period of ** in a compressed self-ignition operating range, and an exhaust air bulb with a rise of a load, to mix external EGR gas in new mind above a predetermined load and to make it flow into a combustion chamber, For example, the optimal amount of internal EGR gas required to produce self-ignition from low loading in an inside load region according to a load is securable. And since the external EGR gas which got cold while producing self-ignition certainly in the combustion chamber central part is distributed over the periphery section of a combustion chamber and rapid combustion can be controlled, the compressed self-ignition combustion stabilized in the still larger load range can be made to perform in a heavy load region.

[0025] According to invention according to claim 6, since the crevice is established in the abbreviation center section of the piston crestal plane in addition to the effect of the invention of claims 1-5, while the shelf life of a swirl style is raised, required volume of combustion chamber is securable.

[0026] Moreover, according to generating of the squish style by the squish generating means, since a cold new mind of having been distributed over the periphery section of a combustion chamber advances between a cylinder head wall surface and a central internal EGR gas layer, the thermal insulation field of combustion gas can spread and the reduction effectiveness of a cooling loss can be increased.

[0027]

[Embodiment of the Invention] Hereafter, the operation gestalt of this invention is explained in full detail with a drawing.

[0028] In drawing 1 and 2, as for a cylinder block and 2, 1 shows the combustion chamber in which a

piston and 3 were formed in of the cylinder head, and 4 was formed of these cylinder blocks 1, a piston 2, and the cylinder head 3.

[0029] The cylinder head 3 is equipped with the exhaust air bulb 8 which opens and closes the intake valve 6 which opens and closes two suction ports 5 and these suction ports 5 and these suction ports 5, an intake valve 6 and two exhaust air ports 7 arranged in opposite, and these exhaust air port 7, and has made it the cross-flow port structure which carries out inhalation of air from the suction port 5 by the side of one and which is exhausted from the exhaust air port 7 of the side else.

[0030] An intake valve 6 and the exhaust air bulb 8 are opened and closed through an air inlet cam 9 and an exhaust cam 10 by the bulb drive system outside drawing, respectively.

[0031] This bulb drive system has considered the closing motion stage of ** and the exhaust air bulbs 6 and 8 as the controllable configuration through the closing motion stage adjustable means 11 and 12 by the engine control unit 23, controls modification of a substantial compression ratio, the amount of internal EGR gas, etc. by an engine's low Naka load region, and is taken as the configuration which can realize the elevated temperature in which compressed self-ignition operation is possible, and a high-pressure condition in it.

[0032] The inlet pipe 13 is connected to the upstream of a suction port 5, the swirl control bulb 14 is attached to this inlet pipe 13 in the location corresponding to one suction port 5, and in case new mind is introduced to a combustion chamber 4, control of a swirl style is enabled.

[0033] The throttle valve 15 for air content adjustment, the air flow meter for inspired-air-volume measurement outside drawing, the air cleaner, etc. are formed in the upstream rather than the swirl control bulb 14 of an inlet pipe 13.

[0034] The swirl control bulb 14 and the throttle valve 15 have made bulb opening controllable through the opening adjustable means 16 and 17 by the engine control unit 23, respectively.

[0035] While the exhaust manifold 18 is connected to the lower stream of a river of the exhaust air port 7 and opening this exhaust manifold 18 and said inlet pipe 13 for free passage by the EGR path 19, the EGR control bulb 20 in which opening control is carried out by the engine control unit 23 in the middle of this EGR path 19 is formed, and the amount of external EGR gas introduced into an inlet pipe 13 is made controllable.

[0036] On the other hand, the abbreviation center position in a combustion chamber 4 is attended at the cylinder head 3, and the fuel injection valve 21 which injects the gasoline fuel supplied from a fuel pump 22 in the direct combustion chamber 4 is formed.

[0037] Moreover, near this fuel injection valve 21, he forms an ignition plug 23, and is trying to make this ignition plug 23 perform jump-spark-ignition combustion at the time of incompressible self-ignition operating range other than a compressed self-ignition operating range, for example, high rotation and heavy load operation.

[0038] In the engine control unit 24, as a signal which shows an engine service condition A signal, a load signal, an air content signal, an intake-air-temperature signal, an exhaust-gas-temperature signal, a fuel-pressure signal, an oil water temperature signal, etc. are inputted whenever [rotational frequency signal / of an engine / and crank angle]. Data processing is performed based on the input signal of these various kinds. Said **, the valve timing of the exhaust air bulbs 6 and 8, It is made to have controlled appropriately to mention each bulb opening of the swirl control bulb 14, a throttle valve 15, and the EGR control bulb 20, the fuel oil consumption of a fuel injection valve 21 and fuel injection timing, and the ignition timing of an ignition plug 23 later, respectively.

[0039] Drawing 3 and 4 show the structure of the crestal plane of a piston 2, have established the abbreviation spherical-surface-like crevice 25 in the abbreviation center section of the crestal plane of this piston 2, and they enable it to have secured required volume of combustion chamber by this crevice 26 while they have been strong till the anaphase of a compression stroke and they can save the flow influence formed in the combustion chamber 4 like the inhalation-of-air line by this crevice 25.

[0040] Moreover, the piston crestal plane around said crevice 25 carries out inclination shaping according to the inclined plane in abbreviation Yamagata of the cylinder head 3 which forms the PENTO roof type combustion chamber 4, and forms the squish area 26 which generates a squish style towards the center of abbreviation of this cylinder head 3 from the arrangement [of an intake valve 6], and arrangement side of the exhaust air bulb 8.

[0041] (**) of drawing 9 and (**) show an example of adjustable control of the valve timing of said ** and the exhaust air bulbs 6 and 8, and at the time of jump-spark-ignition operation, the clausilium stage (EVC) of the exhaust air bulb 8 (EXH) and the valve-opening stage (IVO) of an intake valve 6

(INT) serve as near a piston top dead center (TDC) like the usual four-cycle gasoline engine, and it is set as a necessary valve overlap (O/L).

[0042] While the clausilium stage (EVC) of the exhaust air bulb 8 carries out a tooth lead angle and closes an exhaust air line to halfway to the time of jump-spark-ignition operation at the time of compressed self-ignition operation, the valve-opening stage (IVO) of an intake valve 6 does not exist at all by being controlled by the inhalation-of-air line to carry out a lag and to open to halfway, but the valve overlap in near a piston top dead center is set as a minus overlap condition.

[0043] Thus, by considering as the valve timing which accomplishes minus overlap at the time of compressed self-ignition operation The exhaust air bulb 8 makes the hot existing heat gas by which clausilium of the exhaust air line is halfway carried out, and it is equivalent to the volume of combustion chamber in the time pile up in a combustion chamber 4, and makes it the internal EGR gas to degree cycle. In degree cycle, an intake valve 6 opens an inhalation-of-air line on the way, new mind is inhaled, and compressed self-ignition combustion with the Lean air-fuel ratio is realized near a piston top dead center so that it may mention later by deployment of the heat energy of this internal EGR gas.

[0044] On the other hand, it is returned to the valve timing same as mentioned above as the usual four-cycle gasoline engine, and the inhalation of air and compression of new mind are done at the time of jump-spark-ignition operation, it carries out jump spark ignition with an ignition plug 23, and it is burned by flame propagation.

[0045] Next, the actuation in this operation gestalt is explained in full detail.

[0046] Drawing 2 shows the condition of the stratification-ized process of the new mind and internal EGR gas at the time of compressed self-ignition operation.

[0047] At the time of compressed self-ignition operation, the valve timing of ** and the exhaust air bulbs 6 and 8 is set as minus overlap as mentioned above, and, thereby, a hot burnt gas is shut up as internal EGR gasG in a combustion chamber 4.

[0048] Moreover, while a throttle valve 15 is opened fully, the close by-pass bulb completely of the swirl control bulb 14 is carried out, one side is closed between two suction ports 5 and 5, and as an arrow head A shows from the suction port 5 of another side like an inhalation-of-air line, new mind flows as a swirl style S in a combustion chamber 4.

[0049] The suction port 5 of this another side is constituted as a helical port, and swirl strength may be made to increase by the case.

[0050] The new mind which flowed in the combustion chamber 4 flows along with a cylinder wall, and produces a revolution style in a combustion chamber 4.

[0051] To internal EGR gas G being gas of an elevated-temperature low consistency, since the new mind A is gas of low-temperature high density, the centrifugal force produced by said revolution style becomes larger than internal EGR gas G.

[0052] Consequently, as shown in (b) of drawing 5 , the new mind A is distributed over the periphery in a combustion chamber 4, and internal EGR gas G is distributed over a part for a combustion chamber core, and it laminates these new mind A and internal EGR gas G.

[0053] And by injecting Fuel F from the fuel injection valve 21 arranged from the second half like an inhalation-of-air line in the first half of a compression stroke centering on a combustion chamber, inevitably, this fuel F is distributed over G layers of said hot internal EGR gas of a combustion chamber central part, and compressed self-ignition combustion is performed near a piston top dead center.

[0054] Thus, by carrying out G layers of internal EGR gas in the center in a combustion chamber 4, distributing the new mind A over that perimeter, laminating, injecting and distributing Fuel F over G layers of this internal EGR gas, and making compressed self-ignition combustion perform Internal EGR gas G of the center of a combustion chamber can occur in many parts, the new mind A that temperature is low can form a thermal insulation layer between combustion gas and a combustion chamber wall surface near the cylinder head 3, and combustion can reduce a cooling loss.

[0055] Moreover, an elevated temperature is maintained without being mixed with the new mind A and homogeneity, and internal EGR gas G raises a fuel to the temperature in which self-ignition is possible, and can lessen the amount of internal EGR gas required for compressed self-ignition combustion.

[0056] Consequently, as shown in drawing 7 , to the case (b line) where compressed self-ignition combustion is made to perform by conventional internal EGR gas, new mind, and gaseous mixture with an almost uniform fuel, with this operation gestalt, thermal efficiency has thermal efficiency raised by the expansion width of face alpha which is equivalent to a part for cooling loss reduction, and ratio of specific beat increment as a line shows, and can realize an improvement of specific fuel consumption.

[0057] Moreover, since the inhalation-of-air line which lamination with G layers of internal EGR gas and a new mind A horizon stabilizes injects and distributes Fuel F over G layers of this internal EGR gas from the second half during the period of a compression stroke with this operation gestalt, combustion generating in a combustion chamber central part can be made to be able to ensure, and compressed self-ignition combustion can be stabilized with it.

[0058] Furthermore, as shown in (b) of drawing 5 in the second half of a compression stroke, the new mind A extruded by the squish area 26 flows as squish style S-A toward the core of a combustion chamber 4 along with the 3rd page of the cylinder head, since a cold new mind of having been distributed over the periphery section in a combustion chamber 4 advances between the wall surface of the cylinder head 3, and G layers of central internal EGR gas, the thermal insulation field of combustion gas spreads and the reduction effectiveness of a cooling loss can be heightened.

[0059] The fuel injection by said fuel injection valve 21 performs 1st injection during the minus overlap period of ** and the exhaust air bulbs 6 and 8, as shown in drawing 6, and you may make it an inhalation-of-air line make the 2nd injection perform from the second half in the first half of a compression stroke, as shown in said drawing 5 .

[0060] Thus, by making the 1st fuel injection perform immediately after shutting up hot internal EGR gas G during the minus overlap period of ** and the exhaust air bulbs 6 and 8 (i.e., the inside of a combustion chamber 4), partial oxidation of a fuel can be urged to the condition of being easy to generate self-ignition, and a fuel can be reformed.

[0061] And the fuel by which carried out the internal EGR gas layer which contains this reforming fuel according to swirl generating like an inhalation-of-air line in the center, and reforming was carried out in order to distribute a new gaseous layer over that perimeter and to laminate is held good. In order for the inhalation-of-air line by which lamination with this internal EGR gas layer and a new gaseous layer is stabilized to make the 2nd fuel injection perform in the internal EGR gas layer in which this reforming fuel was held during the period of a compression stroke from the second half, Even if it is a little fuel, while being able to make combustion generating in a combustion chamber central part able to ensure and being able to stabilize compressed self-ignition combustion, the amount of internal EGR gas required for compressed self-ignition combustion can be lessened further.

[0062] A setup of the fuel injection timing covering 2 times in said compressed self-ignition operating range is performed from an engine's low loading in an inside load region, as shown in drawing 8 , in an inside load region, the 2nd fuel injection timing is brought forward with a rise of a load here, and an inhalation-of-air line is set as 1 time in the period of a compression stroke from the second half in fuel injection timing in a heavy load region.

[0063] Moreover, with control of this fuel injection timing, the minus overlap period (sealing period) of ** and the exhaust air bulbs 6 and 8 is controlled to become short with a rise of a load, and it opens the EGR control bulb 20, increases the amount of external EGR gas with a rise of a load, and controls it by the heavy load region to mix external EGR gas in new mind, and to supply in a combustion chamber 4.

[0064] Thus, while being able to stabilize compressed self-ignition combustion by said two fuel-injection-timing setup in an engine's low and inside load region, in order to be able to lessen the amount of internal EGR gas required for compressed self-ignition combustion and to bring the 2nd fuel injection timing forward with a rise of a load in an inside load region, the rise of the combustion temperature by concentration of too much fuel in a combustion chamber 4 is controlled, and it is NOx. The increment in an yield is avoidable.

[0065] Furthermore, when said inhalation-of-air line sets fuel injection timing as 1 time in the period of a compression stroke from the second half, it is avoidable that the generating stage of self-ignition combustion serves as **** in a heavy load region.

[0066] Moreover, in order to shorten the minus overlap period of said ** and the exhaust air bulbs 6 and 8 with a rise of a load, to mix external EGR gas in new mind in a heavy load region and to make it flow in a combustion chamber 4, The optimal amount of internal EGR gas required to produce self-ignition from low loading in an inside load region according to a load is securable. And in a heavy load region, the external EGR gas which got cold while producing self-ignition certainly in the combustion chamber central part can be distributed over the periphery section in a combustion chamber 4, and rapid combustion can be controlled.

[0067] Consequently, since the compressed self-ignition combustion stabilized more in the large load range ranging from the low loading region to a heavy load region can be made to perform, combustion especially rapid in a heavy load region is controlled and slow compressed self-ignition combustion is

made to perform, the heavy load limitation of compressed self-ignition combustion is expandable.

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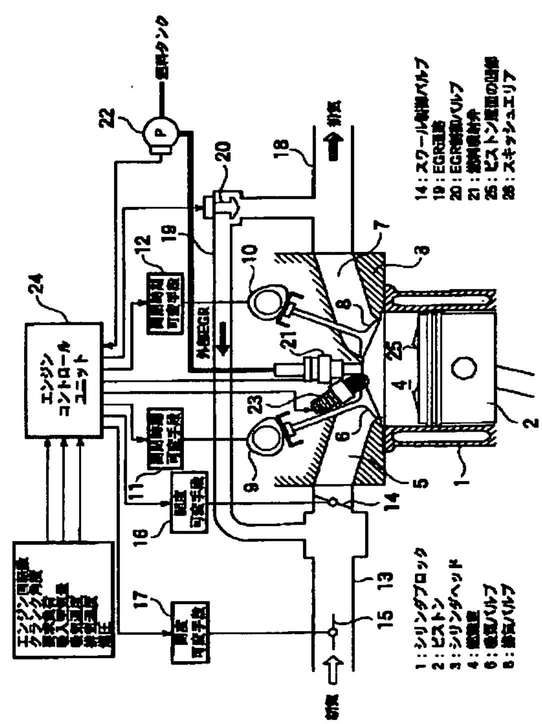
最終頁に続く

(54)【発明の名称】圧縮自己着火式ガソリン内燃機関

(57)【要約】

【課題】　圧縮自己着火燃焼に必要な熱エネルギーとして利用する内部ＥＧＲガス量の低下と冷却損失の低下を図る。

【解決手段】　吸，排気バルブ６，８のマイナスオーバーラップによって燃焼室４内に残留した内部ＥＧＲガスが、新気のスワール流によって燃焼室４内の中央部に分布し、その周囲に新気が分布して層状化されることにより、内部ＥＧＲガスの高温が維持されるため、圧縮自己着火燃焼に必要な内部ＥＧＲガス量を低減できて熱効率を高められ、また、燃焼室４の外周部に分布した新気層が遮熱層となって冷却損失を低減することができる。



【特許請求の範囲】

【請求項１】　ピストンの圧縮作用により燃焼室内の混合気を自己着火して燃焼させる圧縮自己着火式ガソリン内燃機関において、燃焼室内にスワール流を発生可能な吸気系と、燃焼室内に直接燃料を噴射する燃料噴射弁を備えると共に、排気バルブの閉時期（ＥＶＣ）が排気行程途中で吸気バルブの開時期（ＩＶＯ）が吸気行程途中となるマイナスオーバーラップのバルブタイミングに制御可能な動弁機構を備え、圧縮自己着火運転領域で吸，排気バルブのバルブタイミングを前記マイナスオーバーラップに設定して排気の一部を内部ＥＧＲガスとして残留させる一方、新気を燃焼室内へスワール流として導入して、前記内部ＥＧＲガス層を燃焼室内の中央に分布させると共にその周囲に新気を分布させて内部ＥＧＲガスと新気とを層状化させ、前記燃料噴射弁により燃料を主として前記層状化した内部ＥＧＲガス層に噴射，分布させて、圧縮行程で自己着火燃焼を行わせるようにしたことを特徴とする圧縮自己着火式ガソリン内燃機関。

【請求項２】　圧縮自己着火運転領域における燃料噴射弁の燃料噴射時期を、吸気行程後半から圧縮行程の期間中に設定したことを特徴とする請求項１に記載の圧縮自己着火式ガソリン内燃機関。

【請求項３】　圧縮自己着火運転領域における燃料噴射弁の燃料噴射時期を、吸，排気バルブのマイナスオーバーラップ期間中と、吸気行程後半から圧縮行程の期間中とに２回設定したことを特徴とする請求項１に記載の圧縮自己着火式ガソリン内燃機関。

【請求項４】　圧縮自己着火運転領域における燃料噴射弁の燃料噴射時期を、低負荷から中負荷域で吸，排気バルブのマイナスオーバーラップ期間中と、吸気行程後半から圧縮行程の期間中とに２回設定すると共に、中負荷域では負荷の上昇に伴って２回目の燃料噴射時期を早め、かつ、高負荷域では燃料噴射時期を吸気行程後半から圧縮行程の期間中の１回に設定したことを特徴とする請求項１に記載の圧縮自己着火式ガソリン内燃機関。

【請求項５】　圧縮自己着火運転領域における吸，排気バルブのマイナスオーバーラップ期間を負荷の上昇とともに短くなるように制御し、かつ、所定の負荷以上となった時に外部ＥＧＲガスを新気に混入して燃焼室に流入させるようにしたことを特徴とする請求項１～４の何れかに記載の圧縮自己着火式ガソリン内燃機関。

【請求項６】　ピストン冠面の略中央部に凹部を設けると共に、吸気バルブ配置側および又は排気バルブ配置側からシリンダヘッド略中央に向けてスキッシュ流を発生させるスキッシュ発生手段を設けたことを特徴とする請求項１～５の何れかに記載の圧縮自己着火式ガソリン内燃機関。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は圧縮自己着火式ガソリン内燃機関に関する。

【０００２】

【従来の技術】圧縮自己着火燃焼は燃焼室の多点で燃焼が開始されるため燃焼速度が速く、通常の火花点火燃焼に較べて空燃比がリーンな状態でも安定した燃焼を実現することができて燃料消費率の向上が可能であり、また、空燃比がリーンなため燃焼温度が低下することから、排気ガス中のＮＯx を大幅に低減することもできる。

【０００３】また、高回転・高負荷領域では通常の火花点火燃焼を行わせ、低回転・低中負荷領域では前記火花点火燃焼から圧縮自己着火燃焼に燃焼形態を切替えることにより、高回転・高負荷時の高出力確保と、低回転・低中負荷時の燃料消費率向上，ＮＯx の低減化の両立を図ることができる。

【０００４】ガソリンのような自己着火性の低い燃料を用いて圧縮自己着火燃焼を行わせる場合、残留ガスの持つ熱エネルギーを利用することが有効であり、これは例えば特開平１０－２６６８７８号公報に示されているように排気行程から吸気行程に移行する際に、排気バルブと吸気バルブがともに閉となる密閉期間を設けて、残留ガスを積極的に生じさせる所謂内部ＥＧＲを行わせることで実現される。

【０００５】

【発明が解決しようとする課題】ところで、圧縮自己着火燃焼による燃料消費率の向上を更に有効なものとするためには、燃焼中における燃焼ガスから燃焼室壁面への冷却損失を低減することが重要となる。

【０００６】これは、圧縮自己着火燃焼では筒内ガス密度が高いため燃焼ガスから燃焼室壁面への熱伝達率が高くなり、低温の燃焼と言えども冷却損失として失うエネルギーの比率はあまり低下しないためである。

【０００７】しかしながら、前記従来の構成にあっては燃料が吸気ポートに噴射されて新気と混合した状態で燃焼室内に導入され、燃焼室内に残留した内部ＥＧＲガスと均一に混合するようになるため、内部ＥＧＲガスによる燃焼開始時点でのガス温度が高い上に、燃焼室壁面近傍でも発熱が行われ、この結果、燃焼室壁面への冷却損失の低減が図れず、圧縮自己着火燃焼による燃料消費率の向上効果が十分に得られなくなってしまう。

【０００８】また、内部ＥＧＲガスは作動ガスの比熱比を低下させるため、発生した熱エネルギーの圧力への変換が妨げられ、機関の熱効率を低下させてしまう要因となるが、前記従来の構成では混合気と内部ＥＧＲガスとを均一に混合させることから、圧縮自己着火燃焼発生のためには内部ＥＧＲガス量を多量に必要とし、従って、このことによっても圧縮自己着火燃焼による燃料消費率の向上効果を十分に果せなくなってしまう。

【０００９】そこで、本発明は圧縮自己着火燃焼に必要な内部ＥＧＲガス量を低下させることができると共に、

冷却損失を低下させて、圧縮自己着火燃焼による燃料消費率の向上効果を高めることができる圧縮自己着火式ガソリン内燃機関を提供するものである。

【００１０】

【課題を解決するための手段】請求項１の発明にあっては、ピストンの圧縮作用により燃焼室内の混合気を自己着火して燃焼させる圧縮自己着火式ガソリン内燃機関において、燃焼室内に直接燃料を噴射する燃料噴射弁を備えると共に、排気バルブの閉時期（ＥＶＣ）が排気行程途中で吸気バルブの開時期（ＩＶＯ）が吸気行程途中となるマイナスオーバーラップのバルブタイミングに制御可能な動弁機構を備え、圧縮自己着火運転領域で吸，排気バルブのバルブタイミングを前記マイナスオーバーラップに設定して排気の一部を内部ＥＧＲガスとして残留させる一方、新気を燃焼室内へスワール流として導入して、前記内部ＥＧＲガス層を燃焼室内の中央に分布させると共にその周囲に新気を分布させて内部ＥＧＲガスと新気とを層状化させ、前記燃料噴射弁により燃料を主として前記層状化した内部ＥＧＲガス層に噴射，分布させて、圧縮行程で自己着火燃焼を行わせるようにしたことを特徴としている。

【００１１】請求項２の発明にあっては、請求項１に記載の圧縮自己着火運転領域における燃料噴射弁の燃料噴射時期を、吸気行程後半から圧縮行程の期間中に設定したことを特徴としている。

【００１２】請求項３の発明にあっては、請求項１に記載の圧縮自己着火運転領域における燃料噴射弁の燃料噴射時期を、吸，排気バルブのマイナスオーバーラップ期間中と、吸気行程後半から圧縮行程の期間中とに２回設定したことを特徴としている。

【００１３】請求項４の発明にあっては、請求項１に記載の圧縮自己着火運転領域における燃料噴射弁の燃料噴射時期を、低負荷から中負荷域で吸，排気バルブのマイナスオーバーラップ期間中と、吸気行程後半から圧縮行程の期間中とに２回設定すると共に、中負荷域では負荷の上昇に伴って２回目の燃料噴射時期を早め、かつ、高負荷域では燃料噴射時期を吸気行程後半から圧縮行程の期間中の１回に設定したことを特徴としている。

【００１４】請求項５の発明にあっては、請求項１～４に記載の圧縮自己着火運転領域における吸，排気バルブのマイナスオーバーラップ期間を負荷の上昇とともに短くなるように制御し、かつ、所定の負荷以上となった時に外部ＥＧＲガスを新気に混入して燃焼室に流入させるようにしたことを特徴としている。

【００１５】請求項６の発明にあっては、請求項１～５に記載の圧縮自己着火式ガソリン機関において、ピストン冠面の略中央部に凹部を設けると共に、吸気バルブ配置側および又は排気バルブ配置側からシリンダヘッド略中央に向けてスキッシュ流を発生させるスキッシュ発生手段を設けたことを特徴としている。

【００１６】

【発明の効果】請求項１に記載の発明によれば、燃焼室内で内部ＥＧＲガス層を中央にしてその周囲に新気を分布させて、これら内部ＥＧＲガス層と新気とを層状化させ、そして、主としてこの内部ＥＧＲガス層に燃料を噴射するため燃焼は燃焼室中央の内部ＥＧＲガスが多い部分で発生し、かつ、シリンダヘッド近傍に分布する温度の低い新気層が燃焼ガスと燃焼室壁面との間に遮熱層を形成することで冷却損失の低減が図れる。

【００１７】また、このように内部ＥＧＲガスは新気と均一に混らずに高温が維持されて燃料を自己着火可能な温度まで上昇させ、圧縮自己着火燃焼に必要な内部ＥＧＲガス量を少なくすることができるため熱効率を改善でき、前記冷却損失を低減できることと相俟って燃料消費率を一段と向上することができる。

【００１８】請求項２に記載の発明によれば、請求項１の発明の効果に加えて、内部ＥＧＲガス層と新気層との層状化が安定する吸気行程後半から圧縮行程の期間中にこの内部ＥＧＲガス層に燃料を噴射，分布させるため、燃焼室中央部分での燃焼発生をより確実に行わせることができる。

【００１９】請求項３に記載の発明によれば、請求項１の発明の効果に加えて、吸，排気バルブのマイナスオーバーラップ期間中、即ち、燃焼室内に高温の内部ＥＧＲガスを閉じ込めた直後に１回目の燃料噴射を行わせることによってラジカルを生成，増殖させることができ、そして、吸気行程でのスワール発生によりこのラジカルを生成，増殖させた内部ＥＧＲガス層を中央にしてその周囲に新気層を分布させて層状化するためラジカルが良好に保持され、この内部ＥＧＲガス層と新気層との層状化が安定する吸気行程後半から圧縮行程の期間中に、このラジカルが保持された内部ＥＧＲガス層に２回目の燃料噴射を行わせるため、燃焼室中央部分での燃焼発生をより確実に行わせて圧縮自己着火燃焼を安定化することができると共に、圧縮自己着火燃焼に必要な内部ＥＧＲガス量を更に少なくすることができる。

【００２０】請求項４に記載の発明によれば、請求項１の発明の効果に加えて、圧縮自己着火運転領域でも低負荷から中負荷域では吸，排気バルブのマイナスオーバーラップ期間中、即ち、燃焼室内に高温の内部ＥＧＲガスを閉じ込めた直後に１回目の燃料噴射を行わせることによって燃料の部分的酸化を促し、燃料を改質することができ、そして、吸気行程でのスワール発生によりこの改質燃料を含む内部ＥＧＲガス層を中央にしてその周囲に新気層を分布させて層状化するため燃料が改質された状態で良好に保持され、この内部ＥＧＲガス層と新気層との層状化が安定する吸気行程後半から圧縮行程の期間中にこの改質燃料が保持された内部ＥＧＲガス層に２回目の燃料噴射を行わせるため、少量の燃料であっても燃焼室中央部分での燃焼発生をより確実に行わせて圧縮自己

着火燃焼を安定化させることができると共に、圧縮自己着火燃焼に必要な内部ＥＧＲガス量を更に少なくすることができる。

【００２１】しかも、中負荷域では負荷の上昇に伴って２回目の燃料噴射時期を早めるため、燃焼室内の過度な燃料の集中による燃焼温度の上昇を抑制して、ＮＯｘ 発生量の増加を回避することができる。

【００２２】更に、高負荷域では燃料噴射時期を前記吸気行程後半から圧縮行程の期間中の１回に設定するため、自己着火燃焼の発生時期が過早となるのを回避することができる。

【００２３】この結果、低負荷域から高負荷域に亘る広い負荷範囲でより安定した圧縮自己着火燃焼を行わせることができる。

【００２４】請求項５に記載の発明によれば、請求項１～４の発明の効果に加えて、圧縮自己着火運転領域における吸，排気バルブのマイナスオーバーラップ期間を負荷の上昇とともに短くし、所定の負荷以上では外部ＥＧＲガスを新気に混入して燃焼室に流入させるため、例えば低負荷から中負荷域では負荷に応じて自己着火を生じさせるのに必要な最適な内部ＥＧＲガス量を確保でき、かつ、高負荷域では燃焼室中央部分において確実に自己着火を生じさせると共に冷えた外部ＥＧＲガスを燃焼室内の外周部に分布させて急激な燃焼を抑制できるため、更に広い負荷範囲で安定した圧縮自己着火燃焼を行わせることができる。

【００２５】請求項６に記載の発明によれば、請求項１～５の発明の効果に加えて、ピストン冠面の略中央部に凹部を設けてあるため、スワール流の保存性を高められると共に必要な燃焼室容積を確保することができる。

【００２６】また、スキッシュ発生手段によるスキッシュ流の発生によって、燃焼室内の外周部に分布した冷えた新気がシリンダヘッド壁面と中央の内部ＥＧＲガス層との間に進入するため、燃焼ガスの遮熱領域が広がって冷却損失の低減効果を増大することができる。

【００２７】

【発明の実施の形態】以下、本発明の実施形態を図面と共に詳述する。

【００２８】図１，２において、１はシリンダブロック、２はピストン、３はシリンダヘッド、４はこれらシリンダブロック１，ピストン２，およびシリンダヘッド３により形成された燃焼室を示す。

【００２９】シリンダヘッド３は２つの吸気ポート５とこれら吸気ポート５を開閉する吸気バルブ６、およびこれら吸気ポート５，吸気バルブ６と対向的に配置された２つの排気ポート７とこれら排気ポート７を開閉する排気バルブ８を備え、一側の吸気ポート５から吸気して他側の排気ポート７から排気するクロスフローポート構造としてある。

【００３０】吸気バルブ６と排気バルブ８はそれぞれ吸気カム９と排気カム１０を介して図外のバルブ駆動系により開閉される。

【００３１】このバルブ駆動系はエンジンコントロールユニット２３により開閉時期可変手段１１，１２を介して吸，排気バルブ６，８の開閉時期を制御可能な構成としてあり、機関の低中負荷域では実質的な圧縮比の変更、内部ＥＧＲガス量等を制御し、圧縮自己着火運転が可能な高温，高圧状態を実現できる構成としている。

【００３２】吸気ポート５の上流には吸気管１３が接続されており、該吸気管１３には一方の吸気ポート５に対応した位置にスワール制御バルブ１４を付設して、新気を燃焼室４へ導入する際にスワール流の制御を可能としてある。

【００３３】吸気管１３のスワール制御バルブ１４よりも上流には空気量調整用スロットルバルブ１５と、図外の吸気量測定用エアフローメータ，エアクリーナ等を設けてある。

【００３４】スワール制御バルブ１４，スロットルバルブ１５は、それぞれエンジンコントロールユニット２３により開度可変手段１６，１７を介してバルブ開度を制御可能としてある。

【００３５】排気ポート７の下流には排気マニホルド１８が接続されており、該排気マニホルド１８と前記吸気管１３とをＥＧＲ通路１９により連通すると共に、該ＥＧＲ通路１９の途中にエンジンコントロールユニット２３により開度制御されるＥＧＲ制御バルブ２０を設けて、吸気管１３に導入する外部ＥＧＲガス量を制御可能としてある。

【００３６】一方、シリンダヘッド３には燃焼室４内の略中心位置に臨んで、燃料ポンプ２２から供給されるガソリン燃料を直接燃焼室４内に噴射する燃料噴射弁２１を設けてある。

【００３７】また、この燃料噴射弁２１の近傍には点火プラグ２３を設けて、圧縮自己着火運転領域以外の非圧縮自己着火運転領域、例えば高回転・高負荷運転時には、該点火プラグ２３によって火花点火燃焼を行わせるようにしている。

【００３８】エンジンコントロールユニット２４には、機関運転条件を示す信号として、機関の回転数信号，クランク角度信号，負荷信号，空気量信号，吸気温度信号，排気温度信号，燃圧信号，油水温信号等が入力され、これら各種の入力信号に基いて演算処理を行って前記吸，排気バルブ６，８のバルブタイミング、スワール制御バルブ１４，スロットルバルブ１５，ＥＧＲ制御バルブ２０の各バルブ開度、燃料噴射弁２１の燃料噴射量と燃料噴射時期、および点火プラグ２３の点火時期をそれぞれ後述するように適切に制御するようにしてある。

【００３９】図３，４はピストン２の冠面の構造を示しており、該ピストン２の冠面の略中央部には略球面状の凹部２５を設けてあり、吸気行程で燃焼室４内に形成さ

れた流動勢力をこの凹部２５により圧縮行程の後期まで強いまま保存し得ると共に、該凹部２６により必要な燃焼室容積を確保し得るようにしてある。

【００４０】また、前記凹部２５の周囲のピストン冠面はペントルーフタイプの燃焼室４を形成するシリンダヘッド３の略山形の傾斜面に合わせて傾斜成形して、吸気バルブ６の配置側および排気バルブ８の配置側から該シリンダヘッド３の略中央に向けてスキッシュ流を発生させるスキッシュエリア２６を形成している。

【００４１】図９の（イ），（ロ）は前記吸，排気バルブ６，８のバルブタイミングの可変制御の一例を示しており、火花点火運転時は通常の４サイクルガソリン機関と同様に排気バルブ８（ＥＸＨ）の閉弁時期（ＥＶＣ）と吸気バルブ６（ＩＮＴ）の開弁時期（ＩＶＯ）とがピストン上死点（ＴＤＣ）付近となって所要のバルブオーバーラップ（Ｏ／Ｌ）に設定される。

【００４２】圧縮自己着火運転時は火花点火運転時に対して排気バルブ８の閉弁時期（ＥＶＣ）が進角して排気行程中途に閉弁すると共に、吸気バルブ６の開弁時期（ＩＶＯ）が遅角して吸気行程中途に開弁するように制御されて、ピストン上死点付近におけるバルブオーバーラップは全く存在せず、マイナスオーバーラップ状態に設定される。

【００４３】このように圧縮自己着火運転時にマイナスオーバーラップを成すバルブタイミングとすることにより、排気バルブ８が排気行程中途にて閉弁されてその時点での燃焼室容積に相当する高温の既熱ガスを燃焼室４内に滞留させて次サイクルへの内部ＥＧＲガスとし、次サイクルでは吸気行程途中で吸気バルブ６が開弁して新気が吸入され、この内部ＥＧＲガスの熱エネルギーの有効利用により後述するようにリーン空燃比での圧縮自己着火燃焼がピストン上死点付近で実現される。

【００４４】一方、火花点火運転時は前述のように通常の４サイクルガソリン機関と同様のバルブタイミングに戻され、新気を吸気・圧縮して点火プラグ２３により火花点火し、火炎伝播によって燃焼させる。

【００４５】次に本実施形態における動作について詳述する。

【００４６】図２は圧縮自己着火運転時における新気と内部ＥＧＲガスとの成層化過程の状態を示している。

【００４７】圧縮自己着火運転時は前述のように吸，排気バルブ６，８のバルブタイミングがマイナスオーバーラップに設定され、これにより燃焼室４内に高温の既燃ガスが内部ＥＧＲガスＧとして閉じ込められる。

【００４８】また、スロットルバルブ１５が全開されると共にスワール制御バルブ１４が全閉されて２つの吸気ポート５，５のうち一方を閉鎖し、吸気行程で他方の吸気ポート５から矢印Ａで示すように新気が燃焼室４内にスワール流Ｓとして流入する。

【００４９】この他方の吸気ポート５は場合によってヘリカルポートとして構成してスワール強さを増大し得るようにしてもよい。

【００５０】燃焼室４内に流入した新気はシリンダ壁面に沿って流動して燃焼室４内に旋回流を生じさせる。

【００５１】内部ＥＧＲガスＧは高温低密度のガスであるのに対して、新気Ａは低温高密度のガスであるため、前記旋回流により生じる遠心力は内部ＥＧＲガスＧよりも大きくなる。

【００５２】この結果、図５の（イ）に示すように新気Ａは燃焼室４内の外周に分布し、内部ＥＧＲガスＧは燃焼室中心部分に分布してこれら新気Ａと内部ＥＧＲガスＧとが層状化される。

【００５３】そして、吸気行程の後半から圧縮行程の前半で燃焼室中心に配置した燃料噴射弁２１より燃料Ｆを噴射することにより、必然的にこの燃料Ｆは燃焼室中央部分の前記高温の内部ＥＧＲガスＧ層に分布され、ピストン上死点付近で圧縮自己着火燃焼が行われる。

【００５４】このように燃焼室４内で内部ＥＧＲガスＧ層を中央にしてその周囲に新気Ａを分布させて層状化し、この内部ＥＧＲガスＧ層に燃料Ｆを噴射，分布させて圧縮自己着火燃焼を行わせることにより、燃焼は燃焼室中央の内部ＥＧＲガスＧが多い部分で発生し、シリンダヘッド３の近傍では温度の低い新気Ａが燃焼ガスと燃焼室壁面との間で遮熱層を形成して冷却損失を低減することができる。

【００５５】また、内部ＥＧＲガスＧは新気Ａと均一に混らずに高温が維持されて燃料を自己着火可能な温度まで上昇させ、圧縮自己着火燃焼に必要な内部ＥＧＲガス量を少なくすることができる。

【００５６】この結果、図７に示すように熱効率は、従来の内部ＥＧＲガス，新気，燃料がほぼ均一な混合気で圧縮自己着火燃焼を行わせた場合（ｂ線）に対して、本実施形態ではａ線で示すように冷却損失低減分および比熱比増加分に相当する拡大幅αで熱効率を高められ、燃料消費率の改善を実現することができる。

【００５７】また、本実施形態では内部ＥＧＲガスＧ層と新気Ａ層との層状化が安定化する吸気行程後半から圧縮行程の期間中にこの内部ＥＧＲガスＧ層に燃料Ｆを噴射，分布させるため、燃焼室中央部分での燃焼発生を確実に行わせて、圧縮自己着火燃焼を安定化することができる。

【００５８】更に、圧縮行程後半では図５の（ロ）に示すようにスキッシュエリア２６によって押し出された新気Ａがシリンダヘッド３面に沿って燃焼室４の中心に向かってスキッシュ流Ｓ・Ａとして流れ、燃焼室４内の外周部に分布した冷えた新気がシリンダヘッド３の壁面と中央の内部ＥＧＲガスＧ層との間に進入するため、燃焼ガスの遮熱領域が広がって冷却損失の低減効果を高めることができる。

【００５９】前記燃料噴射弁２１による燃料噴射は、図

６に示すように吸，排気バルブ６，８のマイナスオーバーラップ期間中に１回目の噴射を行って、２回目の噴射を前記図５に示したように吸気行程後半から圧縮行程前半に行わせるようにしてもよい。

【００６０】このように吸，排気バルブ６，８のマイナスオーバーラップ期間中、即ち、燃焼室４内に高温の内部ＥＧＲガスＧを閉じ込めた直後に１回目の燃料噴射を行わせることによって自己着火が発生し易い状態に燃料の部分的酸化を促して、燃料を改質することができる。

【００６１】そして、吸気行程でのスワール発生によりこの改質燃料を含む内部ＥＧＲガス層を中央にしてその周囲に新気層を分布させて層状化するため改質された燃料が良好に保持され、この内部ＥＧＲガス層と新気層との層状化が安定する吸気行程後半から圧縮行程の期間中に、この改質燃料が保持された内部ＥＧＲガス層に２回目の燃料噴射を行わせるため、少量の燃料であっても燃焼室中央部分での燃焼発生をより確実に行わせて圧縮自己着火燃焼を安定化することができると共に、圧縮自己着火燃焼に必要な内部ＥＧＲガス量を更に少なくすることができる。

【００６２】ここで、前記圧縮自己着火運転領域での２回に亘る燃料噴射時期の設定は図８に示すように機関の低負荷から中負荷域で行って、中負荷域では負荷の上昇に伴って２回目の燃料噴射時期を早め、そして、高負荷域では燃料噴射時期を吸気行程後半から圧縮行程の期間中の１回に設定される。

【００６３】また、この燃料噴射時期の制御と共に吸，排気バルブ６，８のマイナスオーバーラップ期間（密閉期間）は負荷の上昇と共に短くなるように制御し、かつ高負荷域ではＥＧＲ制御バルブ２０を開弁して負荷の上昇に伴って外部ＥＧＲガス量を増加し、外部ＥＧＲガスを新気に混入して燃焼室４内に供給するように制御する。

【００６４】このように機関の低・中負荷域では前記２回の燃料噴射時期設定によって圧縮自己着火燃焼を安定化することができると共に、圧縮自己着火燃焼に必要な内部ＥＧＲガス量を少なくすることができ、かつ、中負荷域では負荷の上昇に伴って２回目の燃料噴射時期を早めるため、燃焼室４内の過度な燃料の集中による燃焼温度の上昇を抑制して、ＮＯx 発生量の増加を回避することができる。

【００６５】更に、高負荷域では燃料噴射時期を前記吸気行程後半から圧縮行程の期間中の１回に設定することによって、自己着火燃焼の発生時期が過早となるのを回避することができる。

【００６６】また、前記吸，排気バルブ６，８のマイナスオーバーラップ期間を負荷の上昇とともに短くし、高負荷域では外部ＥＧＲガスを新気に混入して燃焼室４内に流入させるため、低負荷から中負荷域では負荷に応じて自己着火を生じさせるのに必要な最適な内部ＥＧＲガス量を確保でき、かつ、高負荷域では燃焼室中央部分において確実に自己着火を生じさせると共に冷えた外部ＥＧＲガスを燃焼室４内の外周部に分布させて急激な燃焼を抑制することができる。

【００６７】この結果、低負荷域から高負荷域に亘る広い負荷範囲でより安定した圧縮自己着火燃焼を行わせることができ、特に高負荷域では急激な燃焼を抑制して緩慢な圧縮自己着火燃焼を行わせるため、圧縮自己着火燃焼の高負荷限界を拡大することができる。

【図面の簡単な説明】

【図１】本発明の一実施形態を概略的に示す断面説明図。

【図２】本発明の一実施形態の圧縮自己着火運転時の吸気過程における燃焼室内の新気と内部ＥＧＲガスとの分布状態を示す略示的平面説明図。

【図３】本発明の一実施形態のピストンの平面図。

【図４】本発明の一実施形態のピストンの断面図。

【図５】本発明の一実施形態の圧縮自己着火運転時の作動説明図で、（イ）は吸気行程を、（ロ）は圧縮行程を示す。

【図６】吸，排気バルブのマイナスオーバーラップ期間中に１回目の燃料噴射を行った場合の作動説明図。

【図７】圧縮自己着火燃焼による熱効率を説明するグラフ。

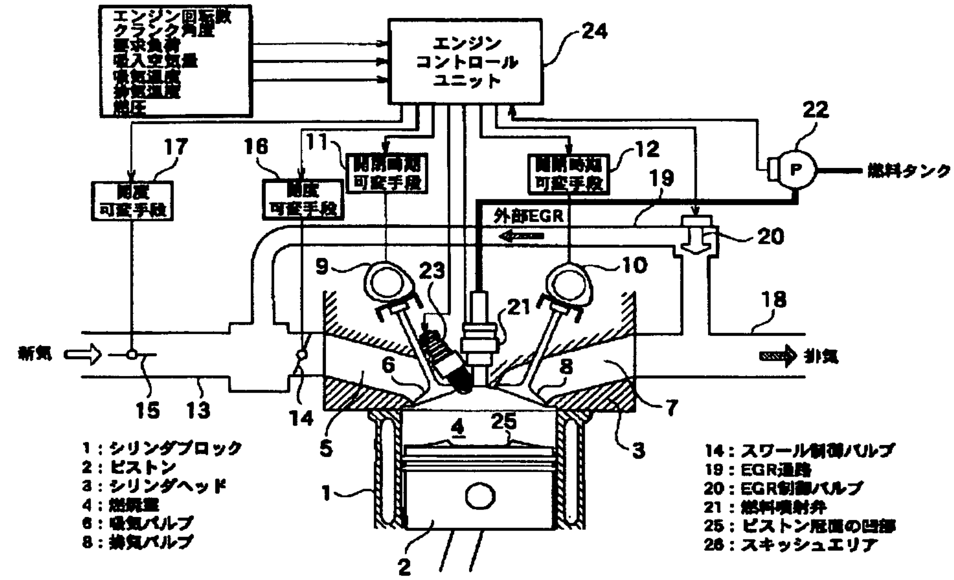
【図８】圧縮自己着火運転時の燃料噴射時期，外部ＥＧＲ率，内部ＥＧＲ量の制御マップ図。

【図９】吸，排気バルブのバルブタイミングの設定の一例を示す図で、（イ）は火花点火運転時を、（ロ）は圧縮自己着火運転時を示す。

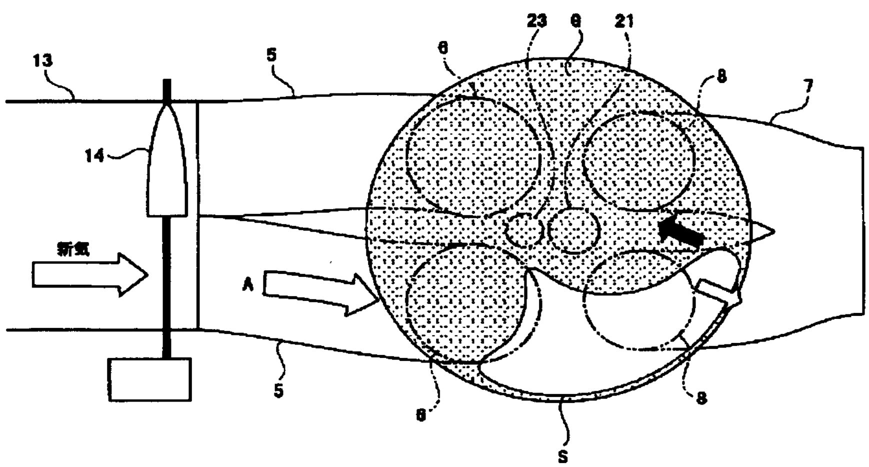
【符号の説明】

１　シリンダブロック
２　ピストン
３　シリンダヘッド
４　燃焼室
６　吸気バルブ
８　排気バルブ
１４　スワール制御バルブ
１９　ＥＧＲ通路
２０　ＥＧＲ制御バルブ
２１　燃料噴射弁
２５　ピストン冠面の凹部
２６　スキッシュエリア

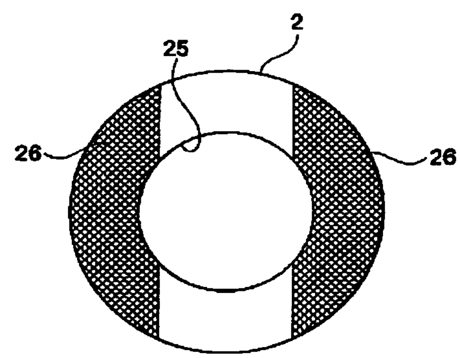
【図１】


エンジン回転数
クランク角度
要求負荷
吸入空気量
吸気温度
排気温度
燃圧
エンジン
コントロール
ユニット
24
22
P
燃料タンク
17
開度
可変手段
16
開度
可変手段
11
開閉時期
可変手段
12
開閉時期
可変手段
19
外部EGR
20
9
23
21
10
18
新気
排気
15
13
14
6
8
7
5
4
25
3
1
2
1：シリンダブロック
2：ピストン
3：シリンダヘッド
4：燃焼室
6：吸気バルブ
8：排気バルブ
14：スワール制御バルブ
19：EGR通路
20：EGR制御バルブ
21：燃料噴射弁
25：ピストン冠面の凹部
26：スキッシュエリア

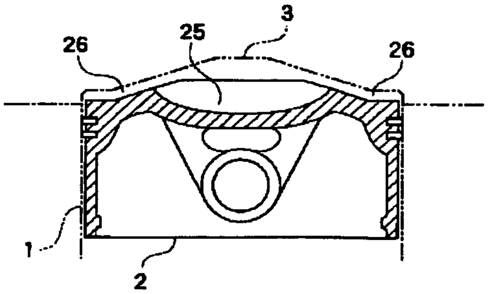
【図２】


13
5
6
23
9
21
8
7
14
新気
A
5
6
S
8

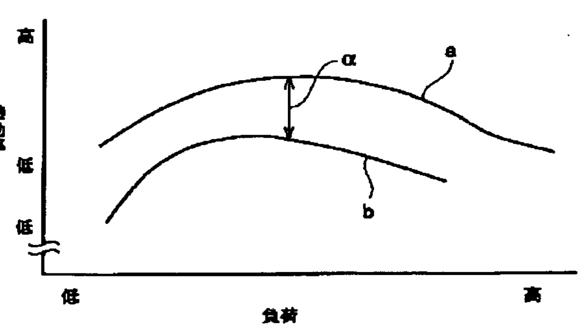
【図３】


2
25
26
26

【図４】

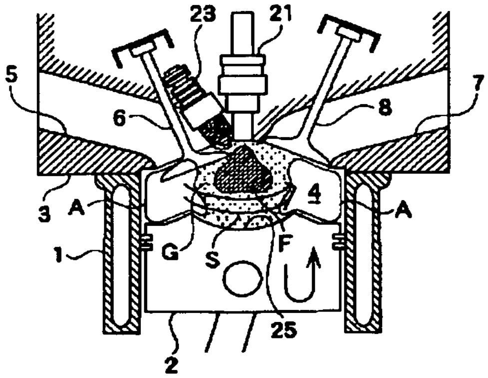

26
25
3
26
1
2

【図７】

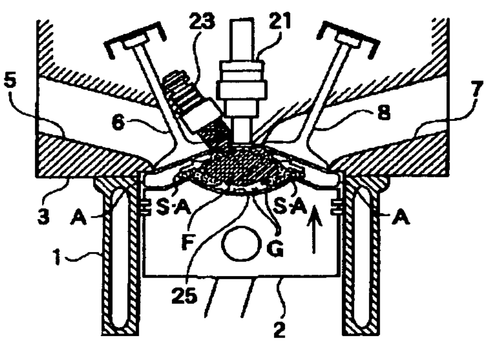

高
低
低
熱効率
α
a
b
低
負荷
高

【図５】

（イ）



（ロ）



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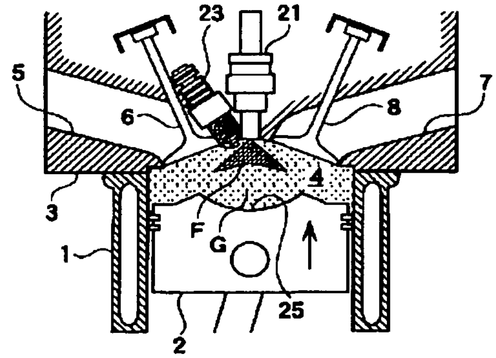
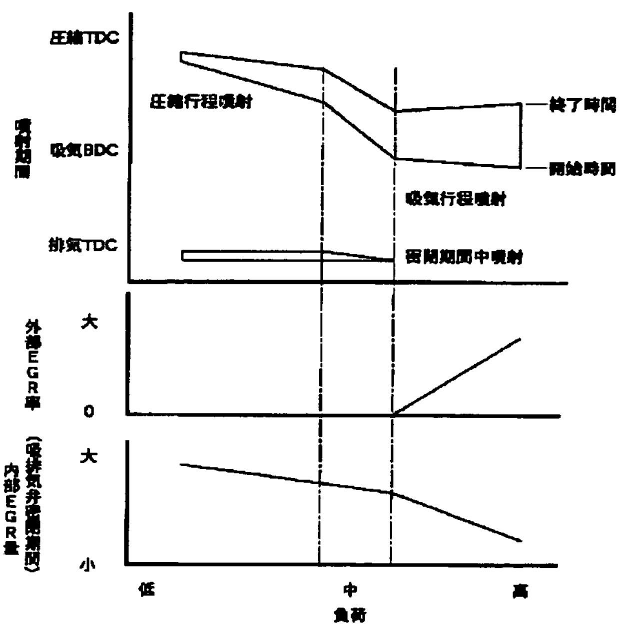
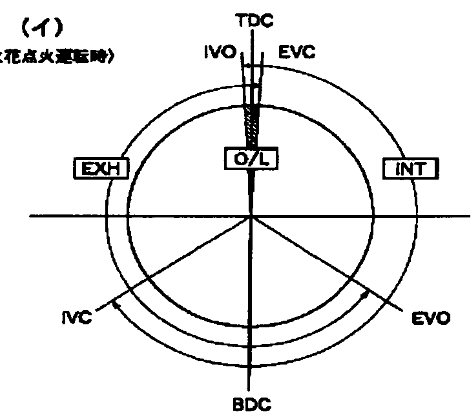


【図８】

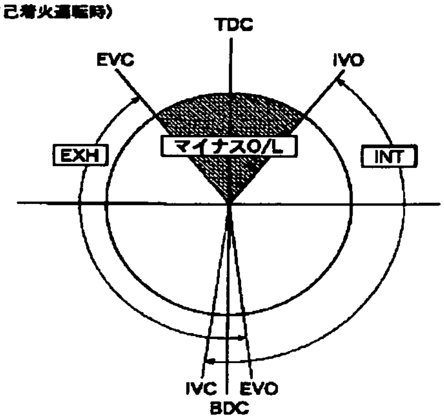


【図９】

（イ）
（火花点火運転時）



（ロ）
（圧縮自己着火運転時）



フロントページの続き

Ｆターム(参考) 3G084 AA00 BA05 BA13 BA15 BA20
BA21 BA23 CA00 CA03 CA04
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